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RESEARCH ARTICLE

Assessment of Geosite and Geomorphosite at South Solok Aspiring Geopark Area

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Abstract

South Solok is one of the five districts designated as the aspiring of the Ranah Minang Geopark. Various reliefs and geological structures cause the diversity of landscapes to be an attraction for tourists and ecosystems with biodiversity. The study intends to identify geosite and geomorphosite in the South Solok area with field observations to describe the state of geology, geomorphology of geosite sites, and geomorphosite. Site assessment is carried out quantitatively with five assessment parameters; scientific, educational, functional, tourist, and posting activities on tourist sites on social media. Field observation found 17 sites classified into four groups, specifically waterfalls, manifestations of hot springs, geomorphological landscapes, and caves. Based on the results of the highest value representation obtained by the Batukapal Cave sites with a value of 44.86% and the lowest at Timbulun Waterfall at 0.1%. Of the 17 sites, four sites are considered the main sites in the research area: Suliti Waterfall, Sapan Maluluang Hot Spring Manifestation, Batukapal Cave, and Camintoran.

Keywords: social media, local community, geodiversity, sustainability

1. Introduction

The introduction describes an overview of geoparks, geosite, and geomorphosite. In addition, describe the geological state of the research area.

1.1 Background

Geopark is a protected area consisting of elements of geological, archaeological, ecological, and cultural values of local communities utilized and preserved. In addition, geological diversity, biodiversity, and cultural diversity are essential elements of an earth park (UNESCO, 2016). Geopark promotes geological features through information media activities, conservation and education, and geological resources through geotourism and sustainable development (Newsome and Dowling, 2018). A geosite or Geological Site is a part of geological heritage rather than a geopark with specific characteristics individually and a combination of several objects and cultural diversity, biodiversity, and cultural part of the story of the trueness of a region (Presiden Republik Indonesia, 2019). Geosite is part of a geographical system with a significant structure, function, and origin, including natural and anthropic heritage (artistic, historical) (Mihai IELENICZ, 2009). Geomorphosite is landforms associated with value, while geomorphological landscapes are part of the earth's surface and can be seen, felt, and exploited by humans. (Reynard, 2005). According to (Kubalíková, 2014), the geomorphosite acts as a landform that has the potential to be a tourism site and has an assessment point of view from humans. Geomorphological or geomorphosite refers to rocks and reliefogenic, which indicates a process used as a historical site, archaeology with a specific frequency, and utilized as tourism. Characteristics in geomorphosite are obtained from elements also found in geosite objectively (Mihai IELENICZ, 2009). Geosite and geomorphosite over time, have degraded from the existence of anthropogenic activities that have the potential to threaten physical properties, resources available in geosite and geomorphosite (Prosser et al., 2018).

South Solok is one of the five districts of the Geopark Ranah Minang with a geological heritage of volcanic landscapes, karsts, rocks, and geological structures equipped with biodiversity ecosystems and cultural diversity. The area does characterize by various reliefs as well as complex geological structures. It becomes the main factor forming the landscape of the research area and provides an attraction for tourists.

They are launching the Aspiring Geopark Solok Selatan part of the Ranah Minang Geopark towards preparing a master plan which is one of the four requirements for proposing a geopark: dossier, geological heritage, masterplan, and governing bodies. The proposed dossier raised the theme “Shallow Geothermal Phenomena and Volcanic Peaks in Southeast Asia.”

Geopark Ranah Minang with dossier “Living in Harmony with the Great Sumatran Fault.” Where it is in the Barisan Mountains and the Sumatra Fault Zone, seven segments pass through the Minang Domain area from Pasaman Angkola Segment, Barumun Segment, Sumpur Segment, Sianok Segment, Sumani Segment, Suliti Segment at the research site that overlaps with the Siulak Segment in the South Solok region, which is actually in the Jambi region (Sieh and Natawidjaja, 2000).

West Sumatra has a beautiful area with a landscape of hills, mountains, lakes, valleys, and karst. Additionally, the diversity of biology, culture, history and relics of the Japanese colonial period are monumented. This is additional to West Sumatra in developing the Ranah Minang Geopark to the National Geopark through its three pillars:

conservation, education, and community economic development.

South Solok Tourism has not been studied much scientifically. As a result of the geosite, these geomorphosites still have problems attracting diverse visitors and long-term solutions to protection and conservation. In addition, the sites' location in an area with inadequate infrastructure, asset maintenance, and processing systems are essential points in the sustainability of geosite and geomorphosite. The research aims to involve geosite and geomorphosite assessments by scientific, educational, functional, tourist, and social media. It then evaluates the scientific and educational value of obtaining the main sites of geosite and geomorphosite and proceeds with revealing their geological, cultural, and biological diversity. Finally, it proposes a planning and development strategy oriented towards tourism promotion and education. This information will help attract students or scientists to take more investigations regarding the acceleration of the South Solok Geopark. In addition, it is increasing the creative economy of local people and knowledge of local people and knowledge of the importance of maintaining, introducing, and preserving tourist sites.

1.2 Research Objective

South Solok is located in the eastern part of West Sumatra Province. South Solok is bordered by Jambi Province to the south, west of South Pesisir Regency, north of Solok Regency, and east of Dhamasraya Regency. Geologically the research area is between the Barisan Mountain and passed by the Suliti Segment, which length 95 km from Mount Talang to Mount Kerinci. The Suliti segment is part of the Sumatra Fault segment. The fault pattern that affects this area is a sliding fault directed northwest-southeast and a normal fault northwest-southeast. The three significant tectonic events influence the geological structure: the Middle Mesozoic Orogenesa, Late Cretaceous – Eocene, and Pliocene Orogenesa Plistosen (Darman, 2013).

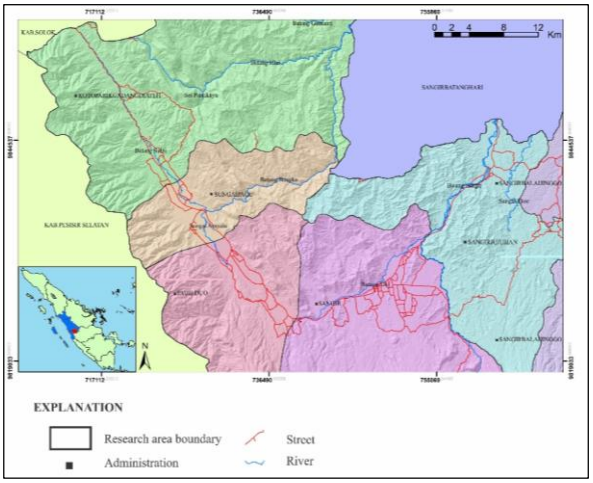

Fig 1. Research area

Stratigraphy of deposited rocks in the Pre-tertiary to Quarternary period consisting of metamorph base rocks (Pre-Mesozoic), metamorph rocks (Mesozoic), metamorph scattered rocks (Mesozoic - Cenozoic), and volcanic rock series (Tertiary - Quarternary) (Rosidi et al., 1976)

Based on RPIJM, South Solok Regency has a tropical climate with temperatures of 20 °C to 33 °C, rainfall of 1,600-4,000 mm / year with humidity ranging from 80%. Excellent flow and spring water. Large rivers generally have sufficient depth, permanent and relatively heavy currents, and hilly landscapes.

2. Methodology

The writing of this research is presented in the reflection of the study (Ansori et al., 2021; Briggs et al., 2021; Brilha, 2016; Hoang et al., 2021; Reynard et al., 2016, 2007) summarized in four stages (Figure 2). The beginning of research was preceded by the study of literature on geology and geomorphology of research areas. Continued field observations are divided into two parts: documentation and descriptive data. The documentation contains information on the location name, coordinates, azimuth, elevation, and image of each site. While geological and geomorphological conditions are based on field observations, map analysis and literature studies are activities of descriptive data. The description does not focus on geomorphological or geological features, but the location's availability of infrastructure, culture, and biology is also outlined. The next stage of a quantitative assessment of geosite and geomorphosite refers to (Gajek et al., 2019; Hausmann et al., 2018) covering five parameters: scientific, educational, functional, tourist, and posting activities on geosite or geomorphosites on social media (table 1). The five assessment parameters above are scientific and educational as the central values.

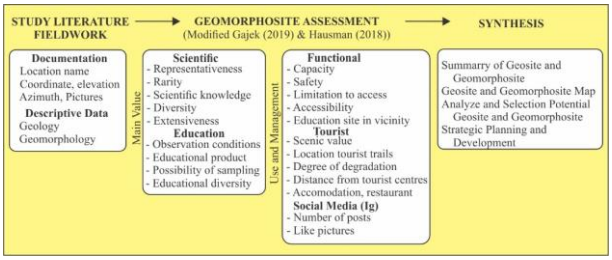

Fig 2. Workflow of research

In contrast, functional, tourist, and social media are secondary site use and management values. This study uses an Instagram platform to look at representations of the number of posts and likes on the images of each geosite and geomorphosite posted. Tourists widely use Instagram to take pictures of tourist sites through mobile apps. In addition, the Application Programming Interface (API) makes it easy to access images on platform searches. (Hausmann et al., 2018).

Quantitative assessment to determine geosite and geomorphosites that have the potential to be the leading site in the acceleration of the South Solok Geopark and evaluate whether it is affected by human activities. The data collected is then sorted to determine which areas have the highest amount of value overall by representing databases based on (1) intrinsic value in scientific, cultural, and aesthetics; (2) the capacity of use on education and function;(3) protective measures against integrity as well as site threats.

The last is a synthesis containing scientific information, maps, photographs, and diagrams. Synthesis is divided into four parts, first presenting the assessment results of each geosite and geomorphosite. Second, advertise the location of each site in the form of a map. Third, analyzing and selecting the potential of geosite and geomorphosite to obtain potential main sites in the research area also explains the state of geology, geomorphology, culture, and biology. The last section provides management advice that can contain the proposal for the protection and management of the site.

3. Result and Discussion

3. 1 Geosite and Geomorphosite

A field survey illustrated in figure 3 shows the distribution of cultural diversity maps, geosites, and geomorphosite in the research area. In this case, 17 geosites and geomorphosites were identified and classified into four types: the manifestation of hot springs, waterfalls, geomorphological landscapes, and caves. The assessment of each geosite and geomorphosite is summarized in table 2.

Geosite and Geomorphosites commonly found are waterfalls of seven sites, geomorphosite with six landscape sites and Batukapal cave as a rare site (figure 4). Waterfalls are formed of geological structures in the form of faults with a waterfall height of 10 - 40 meters and an elevation of 450 meters to 1310 meters. The geomorphological is the appearance of rolling hills, valleys, lowlands, rivers, and mountains that stretch from 250 meters to 1248 meters.

Table 1. Criteria for the quantitative assessment

Variables	Extention	Low Value: 0	Medium value: 1	High value: 2
Scientific	Representativeness	The outcrop lacks typical characteristics	The outcrop features an incomplete	The outcrop features all typical characteristics
	Rarity	>3 similar sites	1 of 3 sites	The only site in the region
	Scientific knowledge	No publications	3-5 publications	More than 5 publications
	Diversity	One feature	2-3 features	>3 features
	Extensiveness	<10 m	10 to 20 m	>20 m
Education	Observation conditions	Vegetation, weathered material obstructs	Vegetation, weathered material partially obstructs	No obstacles to observation
	Education product	Lack of products	1-2 products	More than 2 products
	Didactic potential	For students and specialists only	For pupils of secondary schools	For all levels of education
	Possibility sampling	No possibility	Only with permission	Unlimited
	Education diversity	Geological values only	Geological, biotic	Abiotic, biotic, cultural
Functional	Capacity	<10 persons	11 to 20 persons	>20 persons
	Safety	threats to safety occur	Moderate	No threats at all
	Limitation to access	Problems with access	Access medium	Good access conditions
	Accessibility	>20 min	10 to 20 min	<10 min
	Other education sites	Lack of other sites within a 5 Km radius	2-3 sites within a 5 km radius	>4 sites within a 5 km radius
Tourist	Scenic value	Lack of scenic value	moderate scenic value	Interesting vantage point
	Location to tourists trails	Site located >1 km from a trail	Sited located 100 m – 1 km from a trail	Sited located on a trail or path
	Degree of degradation	The high degree of human impact	A moderate degree of human impact	No visible signs of degradation
	Distance from tourist centers	>15 km away	5-15 km away	<5 km away
	Accommodation and restaurants	>30 km away	10-20 km away	<10 km away
Social Media	Number of posts			
	Likes pictures			

Table 2 Criteria for the quantitative assessment

Sites	Description					
	Scientific	Education	Functional	Tourist	Social Media	
					Image Post	Likes
		A. Hot Spring				
Balun Hot Spring	3	6	7	8	2	58
Ambayan Hot Spring	5	5	6	7	2	108
Sapan Maluluang Hot Spring	9	7	9	7	105	1,484
		B. Waterfall				
Suliti Waterfall	6	6	4	5	130	1,628
Timbulun Waterfall	2	2	3	6	1	32
Kupitan Waterfall	5	6	4	6	45	404
Tansi 4 Waterfall	5	7	6	6	133	2,362
Tansi 3 Waterfall	5	6	4	6	104	4,672
Twin Waterfall	5	7	7	6	198	1,587
Jenjang Waterfall	5	7	9	8	7	104
		C. Geomorphology				
Ampalu River Landscape	7	7	9	9	1	125
Sangir River Landscape	7	7	9	8	17	698
Laras Hill	6	6	9	8	147	774
Bangun Rejo Hill	6	6	8	8	73	1,342
Liki Garden	6	6	9	8	195	3,804
Camintoran	6	6	5	6	342	4,827
		D. Cave				
Stone Cave	10	6	5	7	689	20,365

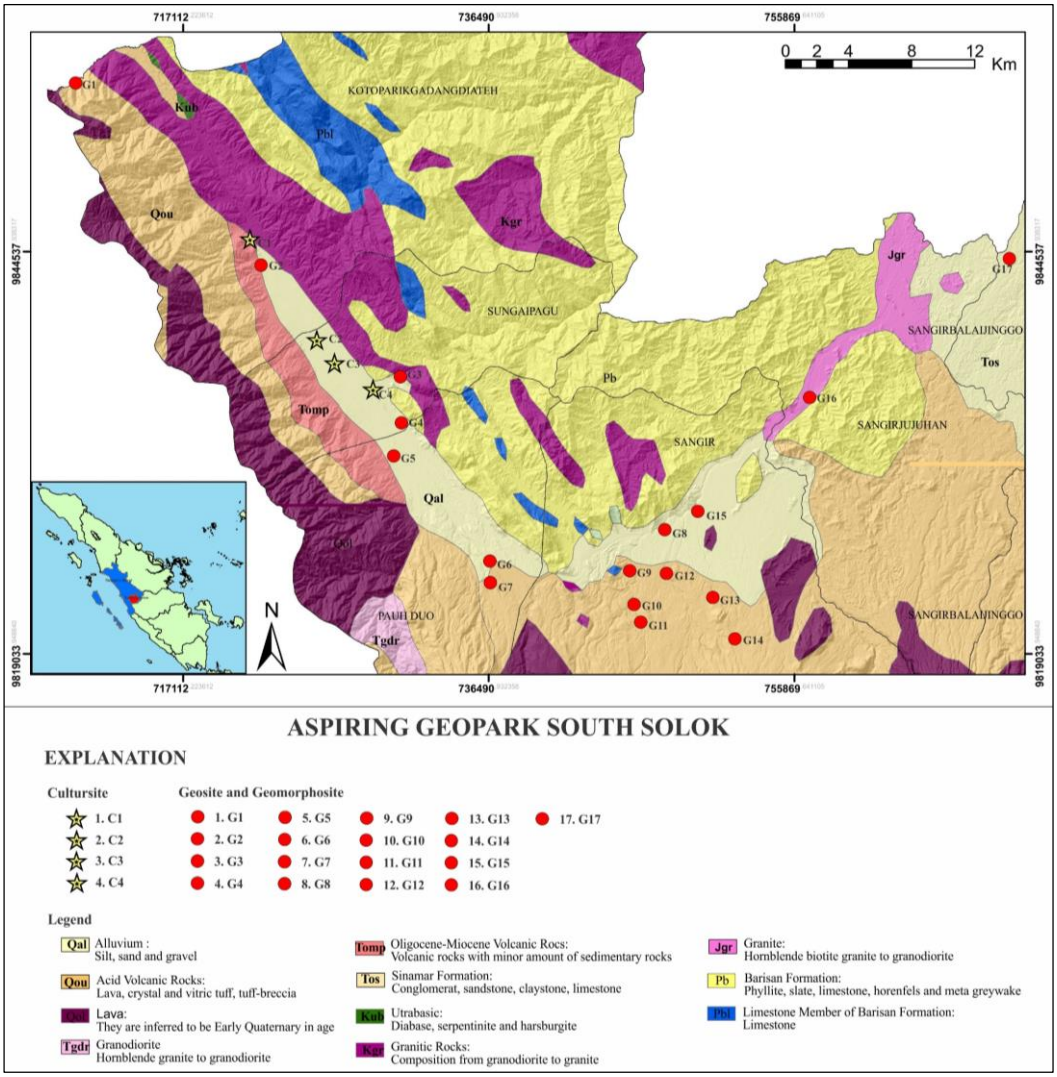

Fig 3. Distribution of cultural, geosite, and geomorphosite diversity maps in the research area using geological base maps (Rosidi, H.M.D and Pendowo, 1996)

Fig 4. Geosite and Geomorphosite Research Area

3.2 Main Geomorphosite Potential

Quantitative assessment criteria for the geosite and geomorphosite of 17 sites are described in a pie chart (Figure 5). The quantitative evaluation of scientific value results represented all aspects of each geosite and geomorphosite—integrated educational interests range from abiotic, biotic, geological, and cultural. The

quantitative evaluation shows scientific and educational scores for the Batukapal Cave. Other sites depict geodiversity with low to moderate scientific and educational value. Secondary value analysis that some inventory sites have a high aesthetic value from the beauty of nature, the scenery that offers a beautiful panorama. It is functionally limited by low access. Meanwhile, the use of social media is at a low to moderate level.

The quantitative assessment showed the highest value at the Batukapal Cave site with a percentage of 44.86% and the lowest percentage at Timbulun waterfall with 0.1%. Representation of geological heritage as well as scientific and educational parameters as the central assessment is proposed by three geosite and one geomorphosite as the main sites in the acceleration of the South Solok Geopark, namely Suliti Waterfall, Sapan Maluluang Hot Spring Manifestation, Batukapal Cave and Camintoran.

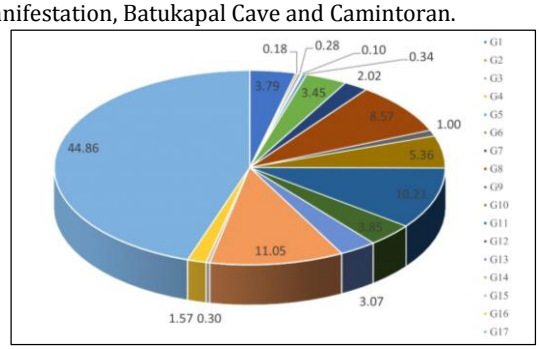

Fig 5. Representation of geosite and geomorphosite quantitative assessment result

3.2.1 Suliti Waterfall

Suliti Waterfall is located in North Pakan Rabaa, Koto Parik Gadang Diateh District, South Solok Regency. The beautiful scenery completed by the height of the waterfall reaching 40 meters is at an elevation of 1310mdpl. The outcrop characteristics describe the features of the waterfall, which indicate the geological structure of the Suliti Segment of the Sumatra fault. This waterfall generally comprises andesite lava lithology by volcano rocks (Qou) (Figure 6). The arrangement of terraced andesite lava rocks close to the waterfall becomes an exciting photo spot, complemented by the splashing of transparent water flow, animal sounds, and soothing air.

The journey to the location can be reached using a vehicle and then followed by walking with an estimated time of ± 2 hours from the parking lot through the geomorphological landscape of hills used by the local community for farming activities. Types of plants in the form of mangosteen fruit commodities that grow up to 7 to 25 meters, rubber trees, and cinnamon. Endemic plants of dewwood (*Podocarpus spp)* with beautiful and delicate fibre quality. In addition, a small Black Paok Topu Bird measuring 16 cm with a characteristic black head, red belly, pale blue patches on the wings, and a short blue eyebrow line behind the eyes. Carrion flowers are found in the Pakan Rabaa area (*Amorphophallus titanum becc*) (Indonesia, 2019).

The slope is sloping too steep, and the vegetation is quite dense. Weathering and erosion activity is high due to the large flow of the river, as well as the appearance of rocks that are the size of boulders and hard compactness.

This location has the potential for special interest tourism as the study of the geological structure, petrography, and geomorphology. Especially the Sumatra Fault study, the Suliti Segment, which is part of the seven segments in Sumatra. The ends of the segments are at the Upper Lake and Lower Lakes, with a width of 4 km, up to Mount Kerinci, which overlaps with the Siulak Segment (Sieh and Natawidjaja, 2000).

Fig 6. (a) Suliti Waterfall (b) showing a geological structure like fault, the composed lava andesite lithology

3.2.2 Sapan Maluluang Hot Spring Manifestation

The manifestation of the Sapan Maluluang Hot Spring is related to active tectonics and quaternary volcanism in the research area through fissures and hot water faults appearing on the surface due to pressure from within the earth (Figure 7). The shape of this hot spring contains water that also produces a foam of water dominated by mud and clay. In addition, there is silica sintered in the interlude of hot springs. Sinter silica has sufficient silk content, and when the temperature is lower than hot springs causes it to settle and become slightly denser (Figure 7).

This hot spring is near the Mount Kerinci area, and there are five source points at the location at an altitude of 866 meters above sea level, surrounded by hills to mountains depicting conical landscapes. Three locations can be reached, while two locations are viewed from a distance. Temperature values range from 43°C -to 91°C and pH 6.8-7.4, with silica sinter electrical resistivity value of 30.41 - 34.19Ωm (Permanda and Putra, 2017).

The local district government has utilized this place as a hot spring tourist attraction from 2014 until now. Access to the location is in good condition to be traveled using a motorcycle or car.

Fig 7. (a) hot springs 1 (b) hot springs 2 (c) hot springs 3 (d) 5 hot springs from a distance (e) Silica sintered interlude on hot spring manifestations 1 (f) hot spring pools.

3.2.3 Batukapal Cave

Batukapal cave is at an elevation of 300mdpl and is a typical landscape of limestone that resembles a ship's cabin. This limestone is part of the Perm-Carbon-aged Row

Formation (Pb) with a shallow marine deposition environment. At the Last Perm of West Sumatra, Sibumasu experienced a collision event, switching in the Barisan Formation (Rosidi et al., 1976).

Raised limestone undergoes dissolution triggered by exposure to meteoric water (rain). This process developed groundwater flow to the karst system and formed a cave morphology with the structure of cave mouths, underground rivers, stalactites, stalagmites, and columns (Figure 8). The cave ceiling has a height of 80 meters and an area of ±27 hectares. At the top is a hole where rays radiate into the cave's walls when the sun rises. The multilevel arrangement of rocks and forming spacious rooms equipped with an alloy of yellow, green, and red colors in each hallway depict the shape of the beautifully painted walls. Multilevel rock arrangements and forming spacious rooms.

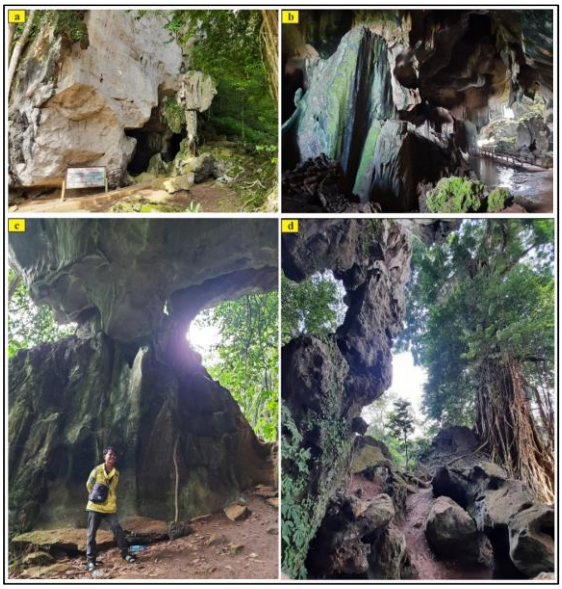

Fig 8. (a) The appearance of the mouth of the cave (b) stalactites, stalagmites, subterranean rivers (c) column (d) Banyan trees.

Batukapal Cave is one part of the Ranah Minang Geopark, which was stipulated by Menteri Energi dan Sumber Daya Mineral (ESDM) in 2021. Furthermore, the same year, Goa Batu Kapal won second place in the Anugrah Pesona Indonesia (API) Award in the hidden paradise category. As a result, the Tourism Conscious Group (POKDARWIS) developed this site, Nagari Sungai Kunyit, Sangir Balai Janggo District, South Solok Regency.

The naming of Batukapal Cave is taken from its unique formation by the local community. According to legend, it was a shipwreck that capsized and cursed and turned into stone. Therefore, each room has a naming from the community starting from bundo kanduang, aline, and batik because it resembles batik carvings and the shape of praying for people.

The beauty of the light reflected from the sunlight emit colorful patterns and can be enjoyed over the bridge from wood as a facility for visitors. It is a nest for leaf-nosed bats (*Rhinolophus*), Seriti birds (*Collocalia esculenta*), and moss-nested swallows (*Collocalia vanikorensis*). In addition, there is a banyan tree (*Ficus banjamina*) with a height of up to 50 meters.

The access needed to the tourist site passes through public and local roads, which are 185 km h from the capital of West Sumatra Province-Padang. 2 km before the location will enter oil palm land with red dirt roads.

3.2.4 Camintoran

The Camintoran site is at an elevation of 1240 meters above sea level, which an area of 16 hectares. Administratively located in Nagari Lubuak Gadang Sangir Subdistrict. This location is used as a campground above the clouds with temperatures reaching 12 °C. In addition, aerospace and agro-tourism tourism objects are developing to improve the community's economy.

The view of Mount Kerinci or Indrapura Peak, with a height of ±3,805 meters, is visible nearby, and a large-scale expanse of morphological landscapes (Figure 9). Landscapes draw geological processes that occur in the research area and play an essential role in the environment, culture, ecosystems, and species.

Camintoran Peak is one of the paragliding spots for athletes to train. Beautiful as well as enchanting scenery from a height. It is said that camintoran land is an ancient city lost in the Swarna Bumi era, which was once located at an altitude of 1,230 meters above sea level at the waist of Mount Kerinci.

The distance from the provincial capital to the location of 172 Km, 2 Km before the area, will pass through a gravel road that is difficult to reach by ordinary vehicles. However, it is not a barrier for visitors to arrive.

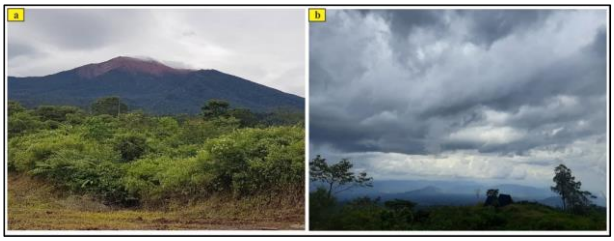

Fig 9. (a) The appearance of the top of Mount Kerinci (b) morphological landscape.

3.3 Strategic Planning and Development

Sustainable development in geosite, geomorphosite to improve community society, enhance the economy and educational facilities for conservation, environment, ecosystems, species, and better site protection.

Some geosite and geomorphosite are degraded due to the natural impact of weathering and erosion. This has the potential to be a risk to the safety of visitors. When the weather rains, the road conditions are slippery and prone to landslide disasters. Therefore, the need to integrate the idea of inheritance in the field of education, launching an inventory of geological heritage in the form of platforms that facilitate the integration of heritage into territorial management. Improving tourist infrastructure and creating well-defined tracks are equipped with interpretation panels to introduce geosite and geomorphosite and reduce human activities' threats. Structured management by prioritizing visitors' safety and comfort and building a Tourism Awareness Group (Pokdarwis) that is active in each sub-district for the smooth running and maintenance of tourist sites.

Conclusion

South Solok is one of the areas included in the Ranah Minang Geopark section. The climate is tropical and has 80% humidity. The succession of geological events part of the Sumatran fault Suliti Segment makes it a natural charm organized in a geological area or geopark. Four main sites are considering scientific and educational parameters from four geosite and geomorphosite classifications: Suliti

Waterfall, Sapan Maluluang Hot Spring Manifestation, Batukapal Cave, and Camintoran.

The 40-meter-high Suliti waterfall is composed of andesite lava lithology. The outcrop reflects the typical waterfall formed from the presence of geological structures. The Sapan Maluluang hot spring with five source points and silica sintered manifestation is formed due to the research area's tectonic activity and quaternary volcanism. Batukapal Cave is a rock landscape resembling a ship cabin that is dissolved so that there is a unique endocardial structure, namely the mouth of the cave, underground river, stalactites, stalagmites, and columns. Finally, Camintoran has a geomorphological landscape on a large scale at an elevation of 1240 meters above sea level. It was one of the options for camping while enjoying the morning chill while enjoying the sunrise until the opening of the peak of Mount Kerinci.

South Solok has launched the preparation of the Aspiring Geopark Solok Selatan masterplan with a dossier with the theme "Shallow Geothermal Phenomena and Volcanic Peaks in Southeast Asia." Geomorphological phenomena and panoramic diversity improve the quality of geological heritage, which is also complemented by biodiversity and cultural diversity ecosystems.

Most visitors are only interested in the beauty of the landscape. Therefore, it is necessary to integrate the idea of inheritance in education and launch an inventory of geological heritage in the form of platforms that facilitate the integration of heritage into territorial management. Improving tourist infrastructure and creating well-defined tracks are equipped with interpretation panels to introduce geosite and geomorphosite and reduce threats associated with human activities.

The sustainable management and development of geosite, geomorphosite aimed at improving people's welfare, economy, and conservation educational facilities also play an essential role in the environment, culture, ecosystems, and species.

Providing provisions to guides helps with safe travel and will improve the quality of tours of each site. In addition, to promoting cultural information, ecosystems add value to each location and tourist's visits.

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